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BATS SURVEYS OF AZURE CAVE AND THE LITTLE ROCKY MOUNTAINS: 1997-1998

A Report to:

USDI, Bureau of Land Management
Malta Field Office
501 S. 2nd Street E
Malta, MT 59538

Submitted by

Paul Hendricks

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ABSTRACT

Surveys of bat activity in the Little Rocky Mountains of Phillips County were conducted in 1997 and 1998 to supplement survey data gathered in 1996. Focus of the 1997-1998 field work was bat use of Azure Cave, the largest bat hibernaculum in the state and one of the largest in the Pacific Northwest and Northern Rocky Mountains regions. Three rock-shelter caves were also evaluated for bat use. Three hibernation counts in Azure Cave (April 1997 and 1998, November 1998), and two trapping sessions at the mouth of Azure Cave (October 1997, September 1998), were conducted during the study.

Counts of hibernating bats in Azure Cave indicated a significant increase since 1978, the first count available for the cave, and the only complete count for the hibernation period. In April 1978, maximum count was 528. Mean counts in April 1997 and 1998 were 1246 and 1120, respectively. Mean count in November 1998 was 1604. Four species of bats were documented in Azure Cave in 1997-1998: Townsend's Big-eared Bat (*Corynorhinus townsendii*), Big Brown Bat (*Eptesicus fuscus*), Little Brown Myotis (*Myotis lucifugus*), Long-legged Myotis (*Myotis volans*). Most use continues to be by species of *Myotis*.

Two nights of netting in October 1997 at the mouth of Azure Cave resulted in capture of 15 bats of three species: Townsend's Big-eared Bat (1), Big Brown Bat (13), Little Brown Myotis (1). Two of the Big Brown Bats were recaptured males marked at the cave in October 1996. Two nights of netting at the cave in September 1998 resulted in capture of 150 bats of six species: Townsend's Big-eared Bat (2), Big Brown Bat (49), Little Brown Myotis (82), Long-legged Myotis (10), Western Small-footed Myotis (*Myotis ciliolabrum*) (3), Western Long-eared Myotis (*Myotis evotis*) (4). One male Big Brown Bat, marked at the cave in October 1996, was present in this sample. Significantly more males were present in netting samples of Big Brown Bat, Little Brown Myotis, and Long-legged Myotis, species for which sample sizes were largest.

Within species, especially Little Brown Myotis and Big Brown Bats, mean weights in September were greater than in June or July. For Big Brown bats, weight declined in October, perhaps indicating that late-flying individuals were still attempting to gain fat reserves prior to hibernation. Alternatively, they may have been seeking additional opportunities for mating at the expense of accumulated fat stores.

Evidence of bat use was found in two of three rock-shelter caves examined. These caves were shallow (21 m maximum depth), and are most likely used as night roosts. Numerous other limestone pockets and rock-shelter caves, as yet unexamined for bat sign, could be used by bats. Most old mine workings are no longer accessible to bats, but a few could provide significant habitat and merit further examination. Most caves and mines of any size in the Little Rocky Mountains are too cold for use as maternity roosts by bats.

To date, seven species of bats (the six previously listed plus the Hoary Bat, *Lasiurus cinereus*) have been verified in the Little Rocky Mountains, and an additional species (Silver-haired Bat, *Lasionycteris noctivagans*) has been reported, based on vocal recordings. A summary of all records for each species is provided.

Unauthorized human entry into Azure Cave, especially if it occurs during the period of occupancy, continues to be a management concern for protection of the bats using the cave as a hibernaculum. Means to improve security of the gate (while maintaining accessibility for bats), and regular visits to Azure Cave to check on gate integrity, should be considered.

ACKNOWLEDGMENTS

This project was made possible through support of the Montana Natural Heritage Program – a collaborative effort of The Nature Conservancy and the Natural Resource Information System – and a Challenge Cost Share agreement with the (former) Lewistown District, Bureau of Land Management. Michelle Williams and Dave Genter secured the initial contract that got this project going. Tim Novotny supervised the supplemental contract that covered the field work reported herein. Pete Feigley, David Kampwerth, Sam Martinez, and Mike Roedel all assisted with the cave counts, trapping, or both. Mike Bogan (USGS) verified tentative identifications on bat skulls recovered from Azure Cave in 1997 and 1998. Dennis Flath (Montana Department of Fish, Wildlife & Parks) provided data on the bats collected during the 1978 cave inventory. Tom Butts shared information from his 1993 and 1994 trips to Azure Cave, and Don Sasse clarified some points about his visit to the cave in 1991. Kevin Ryan and his staff at Zortman Mining, Inc. provided logistical support and access to abandoned mines in 1996 that laid the foundation for the supplemental work of 1997-1998. Thanks to them all.

INTRODUCTION

Azure Cave (Figure 1), located in the Little Rocky Mountains of Phillips County in north-central Montana, was recognized as a significant natural underground feature almost from the date of its discovery in the late 1950's (Howard and Hintzman 1964, Chester et al. 1979). Although not large (total mapped passage is about 580 m, or 1900 ft), the cave is one of the deepest (about 67 m, or 220 ft) in Montana. The cave also harbors some of the finest cave formations in the state, quickly prompting efforts to protect the cave from vandalism. At the same time, the cave was considered for development as a tourist attraction. Although a gate was installed in 1961 (Howard and Hintzman 1964), vandalism and unauthorized entry continued for several years until the gate was modified to make entry more difficult. Following modification of the gate, several authorized entries have occurred, but unauthorized entries still continue, albeit with less frequency than before. Records of the timing and frequency of authorized entries into the cave have not been kept until recently. Current policy is to admit entry only under special circumstances, and internal visits are restricted to inventory and monitoring of cave features.

Early cave inventory and mapping studies mentioned that Azure Cave was used by a large number of bats (Howard and Hintzman 1964, Campbell 1978), but no count was available and the species using the cave remained unverified. A complete cave inventory conducted in 1978 by Chester et al. (1979) not only provided a complete count of bats hibernating in Azure Cave, but also documented seasonal use of the cave by bats, data that have significant management, as well as biological, implications. Bats continue to be the focus of concern nation-wide, because of their vulnerability to disturbance and the loss of many of their traditional roosts, such as caves and abandoned mines (Humphrey 1978, Tuttle 1979, LaVal and LaVal 1980, Gates et al. 1984, Richter et al. 1993). Several species potentially found in the Little Rocky Mountains were on the former Candidate (C2) list maintained by the U.S. Fish and Wildlife Service, and Townsend's Big-eared Bat (*Corynorhinus townsendii*) is currently listed as a BLM Special Status species, and a U.S. Forest Service Sensitive species, in Montana. Recent proposals to expand mining operations in the Little Rocky Mountains near Azure Cave stimulated agency biologists to fund an inventory of the bat fauna in the area of proposed mine expansion, which included Azure Cave. The inventory would provide current baseline data regarding the importance to bats of various landscape features, such as water sources, abandoned mines, as well as caves, from which future management plans can be built. An additional objective was to document more fully the numbers and species of bats using Azure Cave during different seasons.

The first detailed study of bats using Azure Cave since 1978 (Chester et al. 1979) was conducted by Butts (1993), who netted bats at the mouth of Azure Cave in September 1992, and entered Azure Cave to obtain a count of hibernating bats in March 1993. Unfortunately, the entire cave was not examined during Butts' entry, but his netting efforts and counts provide additional data on timing of occupancy of the cave, and he also identified the presence of three species in Azure Cave. Inventory work in 1996, conducted by the Montana Natural Heritage Program (MTNHP), contributed additional data on numbers of bats using Azure Cave and the timing of their occupancy, and identified water sources in the Little Rocky Mountains as significant landscape features for bats (Hendricks and Genter 1997). Five species of bats were captured at the mouth of Azure Cave during netting sessions in June, July, and October (Hendricks and Genter 1997), and six species were identified at water sources in July, using a combination of trapping and electronic monitoring techniques. Altogether, eight species of bats

were recorded during the 1996 inventory: Townsend's Big-eared Bat, Big Brown Bat (*Eptesicus fuscus*), Hoary Bat (*Lasiurus cinereus*), Silver-haired Bat (*Lasionycteris noctivagans*), Western Small-footed Myotis (*Myotis ciliolabrum*), Western Long-eared Myotis (*M. evotis*), Little Brown Myotis (*M. lucifugus*), Long-legged Myotis (*M. volans*). The Silver-haired Bat was the only species determined solely by electronic methods.

In this report, I discuss the results of additional surveys conducted in 1997 and 1998 by MTNHP. Specifically, I present the results of a) three counts of hibernating bats using Azure Cave, and b) two sessions of autumn netting at the mouth of Azure Cave. I combine the results of these surveys with previous data to formulate a more complete picture of seasonal use, species composition, and long-term population trends of bats using the cave as a hibernaculum. I also present results from inspections of other potential roosts in the Little Rocky Mountains, and discuss their significance for bats relative to that of Azure Cave.

METHODS

Surveys at Azure Cave and other potential roost sites in the Little Rocky Mountains were conducted during two visits in 1997 (19-20 April, 7-9 October), and three visits in 1998 (17-18 April, 16-18 September, 12-13 November). Counts of hibernating bats were made in April of each year and during the November visit. Netting sessions and inspection of other potential roosts occurred during September and October visits.

During bat counts in Azure Cave, care was taken to minimize disturbance. Therefore, bats encountered were not handled nor marked while crews were in the cave. Because of concern about disturbance, and inaccessibility of some hibernating bats, species identification of most bats in the cave was not possible. Counts of all bats were made independently by two observers to reduce bias of the total estimate. Route of movement through the cave during counts was similar for each observer. Cave rooms were counted simultaneously by both observers, one room at a time. Location of occurrence within the cave was recorded to document rooms and passages used most often by the bats. Air temperature and relative humidity were recorded using a thermometer and Bacharach sling psychrometer. Remains of bat skulls were collected, tentatively identified, and verified by Mike Bogan (USGS, Museum of Southwestern Biology, University of New Mexico).

Bats were captured at the mouth of Azure Cave using two mist nets (50 denier: one 6 m, one 9 m) set in the same configuration each night. An ANABAT II ultrasonic bat detector was operated during netting to indicate when bats were nearby. Trapping occurred two consecutive nights during each session. Nets were set 30 min before dusk and operated for at least four hours. Captured bats were identified, sexed, measured (weight with a Pesola 30 g scale, forearm length with a dial caliper), examined for reproductive status, and marked with colored celluloid bands. A unique combination of colored bands was used for each night of trapping: 7 October 1997 (single white on right wing), 8 October 1997 (white + purple), 16 September 1998 (white + blue or white + white), 17 September 1998 (single white on left wing).

Rock-shelter caves were located using topographic maps or directions from area residents. Caves were explored to their full extent, while recording climate data and taking preliminary measurements of cave dimensions; the presence or absence of bat spoor was noted. Locations of abandoned mines were obtained in 1996 from maps or the aid of Zortman Mining, Inc. personnel. Visits were limited to external inspection of workings.

Sources for additional data on bats from the Little Rocky Mountains used in the analyses presented here include Chester et al. (1979), Butts (1993), Hendricks and Genter (1997), and Don Sasse (Ashland District, Custer National Forest: personal communication). Where results are statistically analyzed, I follow standard procedures as described in Sokal and Rohlf (1981), with statistical significance assumed when $P < 0.05$. Analysis of variance (ANOVA), two-sample t-test procedures, simple regression, and correlation analyses were run using STATISTIX software.

RESULTS AND DISCUSSION

AZURE CAVE

Hibernation Counts—Total counts of bat occupancy in Azure Cave were 1174-1318 (mean = 1246) on 20 April 1997, 1101-1138 (mean = 1120) on 18 April 1998, and 1457-1751 (mean = 1604) on 12 November 1998 (Figure 2). The count from November probably represents a reasonable estimate of the numbers that would be present if a count were conducted in April 1999, assuming little movement in or out of the cave during winter. Therefore, the November count is considered in this report as equivalent to counts obtained in early spring.

The 1997-1998/1999 counts show a significant increase (Figure 2) in the number of bats using Azure Cave as a hibernaculum since the first complete count (Chester et al. 1978). The three counts reported above were consistently greater than 1100 individuals, more than a doubling of the previous high count of 1978. Counts with questionable figures are those of Butts (1993), which was incomplete, and the MTNHP count of June 1996 (Hendricks and Genter 1997), which probably occurred after spring emergence had begun. Reasons for the dramatic increase of hibernating bats in Azure Cave are unknown, but may relate to the frequency and timing of disturbance by cave visitors in the past. There is some circumstantial evidence that visitation was once more common than in the last 4-5 years.

The number of bats hibernating in Azure Cave since winter 1996/1997 make it one of the largest known bat hibernacula in the Pacific Northwest and Northern Rocky Mountains regions. Azure Cave harbors more wintering bats than any reported hibernaculum in British Columbia (Nagorsen et al. 1993), Oregon or Washington (Perkins et al. 1990), and Wyoming (Priday and Luce 1997). Azure Cave is as large or larger than hibernacula reported from Alberta (Schowalter et al. 1979, Schowalter 1980) and is about the size of the Jewel Cave hibernaculum in South Dakota (Choate and Anderson 1997). Jewel Cave, however, is used by a much greater number of *Corynorhinus townsendii*, as are some other hibernacula in Idaho and Wyoming (e.g., Genter 1986, Priday and Luce 1997)

Counts of bats in Azure Cave conducted throughout the year, using data from all sources, indicate a seasonal pattern of occupancy (Table 1). Apparently few bats use the cave for a roost site between mid-June and late August. Ambient temperature in all portions of the cave beyond the Big Room ranged between 43-45°F (6.5-7.5°C) and 85-100% relative humidity during April entries, and similar data were collected in June 1996, and by Chester et al. (1979) during August 1978. Temperature and relative humidity were somewhat lower at the top of the Big Room during the period of hibernation, nearer the cave entrance. These data indicate Azure Cave remains relatively cold year round, with little seasonal fluctuation in the two environmental climate variables important for bats. Because of constant cold temperature, Azure Cave is not suitable for use as a maternity roost.

In the Little Rocky Mountains, most female *Myotis lucifugus*, *M. volans*, *M. evotis*, and *Eptesicus fuscus* probably select buildings and tree snags or stumps for maternity roosts, as indicated by studies elsewhere (e.g., Schowalter and Gunson 1979, Schowalter et al. 1979, Vonhof and Barclay 1997, Ormsbee and McComb 1998). Female *Corynorhinus townsendii* probably move from Azure Cave to other, warmer caves and rock crevices or abandoned mines for use as maternity roosts (Humphrey and Kunz 1976, Dobkin et al. 1995, Clark et al. 1997).

Hibernating bats were not present uniformly throughout Azure Cave. Between 88.8-89.2% of the total count (based on room and total means) were found widely spread in the Lunch

Room (Figure 1, Table 1) in clusters of up to 30 bats and lesser numbers of solitary individuals. Between 8.3-9.2% occupied the Music Room, with the remainder in the Gnome Home Room area, C Passage, and Big Room. This pattern of occupancy within Azure Cave has been consistent for all previous surveys (Chester et al. 1979, Butts 1993, Hendricks and Genter 1997).

Few bats were identified to species level during hibernation counts. During 18 April 1998, at least 3 of 6 bats in the Big Room were *Eptesicus fuscus*, and on 12 November 1998, 6 *Corynorhinus townsendii* were identified in this same room. By far, however, the vast majority (>99%) of individuals were species of *Myotis*. Pelage color and size (although variable within some species) indicated more than one species was present. Three skulls examined (two from 1997 and one from 1998) belonged to *M. lucifugus* (1) and *M. volans* (2). One *M. volans* was found in the Lunch Room, the other beyond the Gnome Home Room. The single *M. lucifugus* skull was found in a passage beyond the Gnome Home Room. Chester et al. (1979) collected two *M. lucifugus* (1 male, 1 female) and two *M. volans* (1 male, 1 female) from within the cave in April 1978. These specimens are now housed in the non-game collection of the Montana Department of Fish, Wildlife & Parks in Bozeman (accession numbers NG-607 to NG-610). Butts (1993) collected three *M. lucifugus* (1 male, 2 females), one *M. volans* (female), and one *Corynorhinus townsendii* (female) from within the cave in March 1993. Location of these specimens, purportedly deposited in the University of Montana Vertebrate Museum, is not currently known.

Mist-net Trapping—Four nights of netting at the mouth of Azure Cave (7-8 October 1997, 16-17 September 1998) resulted in the capture of 165 individuals of six bat species. During the October session, 15 individuals of 3 species were netted: 1 *Corynorhinus townsendii*, 13 *Eptesicus fuscus*, and 1 *Myotis lucifugus*. Mean ambient temperature during the two nights of netting was 42°F (6.5°C) and 34.5°F (1.5°C), respectively. In September, 150 individuals of six bat species were captured: 2 *C. townsendii*, 49 *E. fuscus*, 82 *M. lucifugus*, 10 *M. volans*, 4 *M. evotis*, 3 *M. ciliolabrum*. The proportions of bat species in the samples varied significantly ($G = 6.932$, $df = 2$, $P < 0.05$) during the two nights in September. *M. lucifugus* and *E. fuscus* comprised 42.3% and 38.8%, respectively, of the catch on the first night (n = 67 bats), and 63.9% and 27.7%, respectively, of the catch on the second night (n = 83 bats). Mean ambient temperature during the two nights of netting was 74°F (23.5°C) and 70.5°F (21.5°C), respectively.

A total of 218 individual bats of six species (all of the species netted during September 1998) have been captured at Azure Cave, of which 217 were identifiable to species (Table 2). All six species have been documented at the cave on more than one occasion. The mouth of Azure Cave has been netted in June, July, August, September, and October. Spring emergence and autumn swarming periods provided the largest captures/net hour (Figure 3). Netting in July, when maternity roosts typically are active, produced the fewest captures, supporting the pattern of cave occupancy determined from internal counts. The internal counts and external trapping indicate that Azure Cave is used primarily as a hibernaculum, less so as a summer night and day roost, and probably not at all as a maternity roost.

Sex ratio of captured bats favored males (80.3% of 218 individuals) in samples from Azure Cave (Table 2), a pattern typical for caves and mines in this region (e.g., Schowalter 1980, Bogan et al. 1996, Choate and Anderson 1997). Males were significantly more abundant (Table 2) in samples of the three most common bat species: *Myotis lucifugus* (86.9% of 107 individuals), *Eptesicus fuscus* (81.3% of 80 individuals), *M. volans* (78.6% of 14 individuals).

Sex ratios for the three least abundant species in the Azure Cave samples (*M. ciliolabrum*, *M. evotis*, *Corynorhinus townsendii*), all represented by five or six individuals, favored females. Why there is this difference is not clear, but it likely results from differences in roost site selection and/or migratory habits between species and sexes.

Both *Myotis lucifugus* and *Eptesicus fuscus* gained weight between summer and autumn activity periods. Between June and September, *M. lucifugus* added an average of nearly 3 g (June: 6.8 ± 0.4 g, n = 14; September: 9.7 ± 1.1 g, n = 82), a significant weight increase (t = 17.58, $P < 0.001$). Sexes were pooled in this analysis because weight differences between sexes were not statistically significant, although females were slightly heavier than males (by 0.6 g) in June; each sex averaged 9.7 g in September.

Female *Eptesicus fuscus* were heavier than males in September and October (t-tests, $P <$ 0.01) by 2.5 and 2.6 g, respectively. There are no weight data for female *E. fuscus* from spring or summer, but they are probably heavier than males at that time as well. There was a significant correlation ($r = 0.508$, $P < 0.001$) between September forearm length and weight for this species in the Little Rocky Mountains. Forearm length of September female *E. fuscus* (46.9 ± 1.5 mm, n = 11) was, on average, significantly greater ($t = 4.24$, df = 46, $P < 0.001$) than for males (45.1 ± 1.4 mm, n = 37). October females weighed less (21.8 ± 1.7 g, n = 4) than September females (24.2 ± 2.5 g, n = 11), although the difference was not statistically significant ($t = 1.81$, $P =$ 0.093). Weight of male *E. fuscus* was least (Table 3) in July, greatest in September, and showed a significant decline from September to October. The differences between mean weights among time periods were statistically significant (Bonferroni tests, $P < 0.05$).

Perhaps lighter weight in late-flying *Eptesicus fuscus* indicates that these individuals are still attempting to accumulate fat reserves prior to hibernation. Alternatively, bats continuing activity later than average may trade a loss in accumulated fat stores for increased opportunities of mating. It is unlikely that late-flying bats were young of the year (see Schowalter 1980). Forearm length of male *E. fuscus* (Table 3) varied significantly among time periods (one-way ANOVA: $F_{2,64} = 3.63$, $P = 0.0313$), but October males had significantly longer forearms than September males (Bonferroni test, $P < 0.05$). Also, most males exhibited the swollen finger joints typical of adult bats (Anthony 1988). The generality of lighter weight for late-flying bats of other species in the Little Rocky Mountains is not yet clear, due to insufficient samples for comparisons. Schowalter (1980), however, noted similar weight loss in samples of late-flying adult *M. lucifugus* measured after late August in Alberta, and a single male *Myotis volans* captured at Azure Cave in October weighed 8.9 g, slightly less than the mean of 9.7 g (range 9.0-10.5 g) for nine September males.

OTHER SITES

Two Hands Cave—This rock-shelter cave (T25N R25E S30SWSE), at 1280 m (4200 ft) elevation, was first visited during July 1996 (Hendricks and Genter 1997). Pictographs are present in a few places on the walls, providing the cave with its name. *Eptesicus fuscus* and unidentified *Myotis* were identified with a bat detector at the mouth of the cave, and one pass by the Silver-haired Bat (*Lasionycteris noctivagans*) was also noted. This cave was visited again on 8 October 1997 and 17 September 1998. Scattered bat guano was found in the cave both times, to at least 11 m (36 ft) from the entrance. The cave has a large opening, and ascends into the hillside about 21 m (69 ft) to a small room. Woodrats (*Neotoma cinerea*) and feral pigeons also use the cave. No bats were seen during any visit during the day, indicating it is most likely used

as a night roost. On 8 October, internal temperature 11 m in was 13.5°C (56°F) at 11:40, with relative humidity = 44%. Outside ambient temperature and humidity were 3°C (37.5°F) and 77%, respectively, indicating that this cave traps warm air.

Grouse Gulch Cave—This rock-shelter cave (T25N R25E S30SWSW), at 1280 m (4200 ft) elevation, was visited on 8 October 1997. The cave has a large opening and ascends into the hillside for 15.7 m (51.5 ft). A few pictographs are present on the cave walls. Bats were not seen, nor was any bat guano noted. However, the cave floor is covered with copious amounts of pigeon and woodrat droppings, making detection of bat guano difficult. The cave traps warm air, but no measurements were made at the time of the visit (12:30). This site, like Two Hands Cave, is probably used as a night roost.

"Smoke Hole" Cave—This rock-shelter cave (T25N R25E S16NWSWNW), just north of Zortman at 1402 m (4600 ft) elevation, was visited on 17 September 1998. The cave has two entrances. The main entrance is 2 m high by 6 m wide, a smaller opening is 1.6 m high by 1.9 m wide and slightly downhill and north from the main opening. From the main opening, the cave gently descends into a wide room to a stone wall 9 m from the entrance that was erected by earlier visitors. From here, two crawlways continue, the left passage for about 8 m, the right passage for about 7 m. Maximum cave length from the entrance is about 17 m (56 ft). At the time of the visit (11:30), air temperature was 11.5°C (62°F) 9 m from the entrance, colder than outside ambient (27°C, 80°F). From the secondary entrance, a short passage ascends to the main room. Scattered bat guano was present throughout the main room, but no bats were seen. This cave is probably used primarily as a night roost.

Abandoned Mines—Several mine sites were visited briefly in 1996, none of which was revisited in 1997-1998. The only visited mine mentioned in Hendricks and Genter (1997) was the Pink Eye Pearl Adit #1 (T25N R25E S7/T25N R24E S12), which was monitored overnight on 9 July and showed significant activity by bats, including *Eptesicus fuscus* and *Corynorhinus townsendii*. Of the workings visited, this was the most promising site for bats. The mine was not entered, however. Other mine workings examined externally in 1996, but not entered, included the Linda K (T25N R25E S7SWNW), at 1622 m (5320 ft). The adits were buried by gravel and waste rock, and are not currently suitable for bats. The adits of the Ruby Mine (T25N R25E S7SESW), at 1463 m (4800 ft), were also buried by gravel. Underground tunnels may intersect the Ross Pit, and there may be significant underground workings. If reopened, this mine may provide suitable bat habitat. The Badger King mine (near the Pink Eye Pearl, on Glory Hole Creek) was comprised of 3 adits, all of which are blocked, although slight airflow was detected. There was no evidence of bat use at the small entrance openings, but enlarging the entrances may provide suitable bat habitat. A small collection of adits in Dry Gulch (T25N R24E S26NENE), at about 1402 m (4600 ft), were examined. All were collapsed or mostly trenches, and unsuitable for bats.

SPECIES SUMMARIES

***Myotis californicus* (California Myotis)**—One male was reported captured at Azure Cave on 3 June 1996 (Hendricks and Genter 1997). The record is now considered questionable, based on

further examination of the written details, and this species should not be considered verified for the Little Rocky Mountains.

***Myotis ciliolabrum* (Western Small-footed Myotis)**—This species has been documented in the Little Rocky Mountains five times, represented by 6 individuals (Table 2). One female was captured at Azure Cave on 3 June 1996, 1 female was captured at Pond #1 below Azure Cave on 9 July 1996, 1 female was captured at Azure Cave on 22 October 1996, 2 females were captured at the mouth of Azure Cave on 16 September 1998, and 1 male was captured at the mouth of Azure Cave on 17 September 1998. These records fill a large hiatus in the known distribution for Montana (Hoffman et al. 1969, Swenson 1970, Swenson and Bent 1977).

***Myotis evotis* (Western Long-eared Myotis)**—This species was first recorded in the Little Rocky Mountains by Butts (1993), who captured a male on 29 September 1992 at the mouth of Azure Cave. Other records include 1 male captured at Pond # 1 below Azure Cave on 9 July 1996 (Hendricks and Genter 1997), and 1 male and 3 females captured at the mouth of Azure Cave on 16 September 1998. Recorded calls of this species were reported at Azure Cave on 7 July 1996 (Hendricks and Genter 1997). These records fill a hiatus in previous reports from Montana (Hoffmann et al. 1969, Swenson and Shanks 1979).

***Myotis lucifugus* (Little Brown Myotis)**—This species is the most abundant bat documented from the Little Rocky Mountains. Chester et al. (1979) collected 1 male and 1 female (Montana Fish, Wildlife & Parks collection, NG-607, NG-609) from inside Azure Cave on 2 April 1978. Butts (1993) captured 2 males each on 28 and 29 September 1992 at Azure Cave, and collected 1 male and 2 females from inside Azure Cave on 5 March 1993. Hendricks and Genter (1997) reported 12 males and 3 females captured at Azure Cave on 3 June 1996, and 1 male netted at Pond #1 below Azure Cave on 9 July 1996. Other records include 1 female at Azure Cave on 8 October 1997, 24 males and 5 females at Azure Cave on 16 September 1998, 51 males and 2 females at Azure Cave on 17 September 1998. One skull (MTHP 4063) was collected in Azure Cave on 20 April 1997. This species has been reported during winter in Montana only twice before (Swenson and Shanks 1979), although it is widespread in the state.

***Myotis volans* (Long-legged Myotis)**—Chester et al (1979) collected 1 male and 1 female (Montana Fish, Wildlife & Parks collection: NG-608, NG-610) from inside Azure Cave on 2 April 1978. Butts (1993) collected a female from inside Azure Cave on 5 March 1993. Hendricks and Genter (1997) reported 1 male captured at Azure Cave on 22 October 1996. Other records include 3 males and 1 female captured at Azure Cave on 16 September 1998, and 6 males captured at Azure Cave on 17 September 1998. Two skulls have been collected in Azure Cave (MTHP 4062, MTHP 4075), on 20 April 1997 and 18 April 1998. There are few records of this species in eastern Montana (Hoffmann et al. 1969, Jones et al. 1973, Swenson and Bent 1977, Swenson and Shanks 1979), and even fewer winter records.

***Eptesicus fuscus* (Big Brown Bat)**—This species is the second most abundant bat documented from the Little Rocky Mountains and the first species recorded. A specimen (sex?) was collected in Zortman on 30 July 1910 by H. E. Anthony, and is now housed in the U.S. National Museum (USNM 169668). Butts (1993) captured 2 males at Azure Cave on 28 September 1992, and 3 males at Azure Cave the following night. Hendricks and Genter (1997) reported 1 male captured

at Azure Cave on 7 July 1996, 2 males captured at Pond #1 below Azure Cave on 8 July 1996, 5 more males captured at the same site the following night, 9 males and 1 female captured at Azure Cave on 22 October 1996, and 5 more males captured there the following night. Other records include 6 males and 1 female captured at Azure Cave on 7 October 1997, 4 males and 2 females captured at Azure Cave on 8 October 1997, 3 individuals seen in Azure Cave on 18 April 1998, 23 males and 4 females captured at Azure Cave on 16 September 1998, and 16 males and 7 females captured at Azure Cave on 17 September 1998. Two males of 15 *E. fuscus* marked in October 1996 at Azure Cave were recaptured there in October 1997, and one of the 1996 males was recaptured at Azure Cave in September 1998. These records indicate some degree of site fidelity to Azure Cave for this species. Hendricks and Genter (1997) listed this species at 10 additional sites (ponds and forested locations) in 1996, based on vocal recordings. There are no published winter records for this species in Montana, and only 1 winter specimen (Ravalli County).

***Corynorhinus townsendii* (Townsend's Big-eared Bat)**—Butts (1993) was the first to document this species in the Little Rocky Mountains, with 1 female captured at Azure Cave on 29 September 1992. Butts also reported 11 (sex?) in Azure Cave on 5 March 1993, a female of which was collected. Hendricks and Genter (1997) reported 1 male captured at Azure Cave on 7 July 1996, and vocal recordings from 4 additional sites in July. Other records include 1 male captured at Azure Cave on 8 October 1997, 2 females captured at Azure Cave on 16 September 1998, and 6 (sex?) in Azure Cave on 12 November 1998. All reports of this species in Azure Cave have been from near the entrance gate, through the Big Room, to near the bottom of the 40 ft drop (Figure 1). These records fill a hiatus in the documented distribution in Montana (Hoffmann et al. 1969, Swenson and Shanks 1979). The Little Rocky Mountains is along the northeastern limit of the distribution in the Northern Great Plains, and this species has yet to be reported from Alberta or Saskatchewan (van Zyll de Jong 1985, Smith 1993).

***Lasionycteris noctivagans* (Silver-haired Bat)**—This species is not yet verified by a captured individual or specimen. Hendricks and Genter (1997) reported it, based on vocal recordings, at 3 sites below Azure Cave, and also at the mouth of Two Hands Cave, all on 9 July 1996. This species tends to use tree cavities for roosts, so its absence from trapping samples at Azure Cave is not surprising. The species is widespread across the state in summer, apparently migrating out of Montana during winter.

***Lasiurus cinereus* (Hoary Bat)**—Hendricks and Genter (1997) were the first to report this species from the Little Rocky Mountains. Two males and 2 females (lactating) were captured at Pond #1 below Azure Cave on 9 July 1996. Other records (Hendricks and Genter 1997), based on vocal recordings, include 3 other ponds on 7 and 8 July 1996. These records fill a large hiatus in the known distribution for Montana.

RECOMMENDATIONS

Security of Azure Cave is a high priority management concern for the Little Rocky Mountains. Azure Cave is now known to be one of the largest bat hibernacula in this region of North America. Fall, winter, and spring are the most critical periods for bat use of Azure Cave. Summer use of the cave is minimal. In 1998, Azure Cave experienced at least one unauthorized entry some time during summer by an unknown number of individuals. Fortunately, the cave was not entered when bats were hibernating, but that scenario could have occurred. In fact, several parties could have entered the cave at any time of the year with little likelihood of detection or deterrence. The mechanism whereby the gate was locked was especially vulnerable to any party of moderate motivation for gaining entry. The recommendations that follow are essentially those from the previous report. They are worth repeating here.

1) The gate on Azure Cave does not quite follow recommended construction specifications (e.g., Tuttle and Taylor 1994), especially as it pertains to security from human intrusion. Replacement of the gate with a recommended design should be considered as a future management priority.
2) Secure the gate with a protected lock, not an exposed chain. Experience has now shown that a chain is easily bypassed. Mechanisms for protecting gates from unauthorized entry are part of recommended gate designs.
3) Change the lock on the cave gate every year or two to reduce likelihood of unauthorized access with "lost" or duplicate keys. Visit Azure Cave once a month to check gate integrity, especially from April-October when the site is most accessible.
4) Maintain a logbook of visitors to Azure Cave at the Malta Field Office (or appropriate jurisdictional office). This will provide a record of authorized activity at the cave upon which future changes in admission policy can be based. It also provides data with which population trends in the overwintering bat population might be correlated.
5) Conduct counts of hibernating bats in Azure Cave every 2-3 years in the presence of active mine expansion, or every 3-5 years in the absence of mining threats or other disturbance. It is preferable to conduct the count in April, so that counts can be compared across years (there are three complete April counts available: 1978, 1997, and 1998). Dramatic declines should be cause for alarm. The party conducting the counts should include at least one experienced bat biologist. No more than three persons should be in the party entering the cave, to minimaze disturbance while maintaining a reasonable level of safety.
6) Continue to monitor bat activity at nearby ponds every 2-3 years, so long as mine expansion is a reasonable possibility. Water sources in the area are extremely significant to the bat fauna of the Little Rocky Mountains (Hendricks and Genter 1997), including the individuals occupying Azure Cave. Management for bats should include availability and access to water, even to the point of constructing new ponds if mine expansion proceeds and eliminates some water sources.
7) Continue with surveys of other caves and abandoned mines, which may provide significant roost sites for bats during summer. Information gained will also provide a more complete picture of the significance of Azure Cave to the bat fauna of the Little Rocky Mountains.

LITERATURE CITED

Anthony, E. L. P. 1988. Age determination in bats. Pp. 47-58, *In* Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C. 533 pp.

Bogan, M. A., J. G. Osborne, and J. A. Clarke. 1996. Observations on bats at Badlands National Park, South Dakota. Prairie Naturalist 28:115-123.

Butts, T. W. 1993. Azure Cave bat surveys, Little Rocky Mountains, Montana: September 1992 and March 1993. Westech, unpublished report. 13 pp.

Campbell, N. P. 1978. Caves of Montana. Montana Bureau of Mines and Geology, Bulletin 105. 169 pp.

Chester, J. M., N. P. Campbell, K. Karsmizki, and D. Wirtz. 1979. Resource inventory and evaluation, Azure Cave, Montana. BLM unpublished report. 55 pp.

Choate, J. R., and J. M. Anderson. 1997. Bats of Jewel Cave National Monument, South Dakota. Prairie Naturalist 29:39-47.

Clark, B. K., B. S. Clark, and D. M. Leslie, Jr. 1997. Seasonal variation in use of caves by the endangered Ozark Big-eared Bat (*Corynorhinus townsendii ingens*) in Oklahoma. American Midland Naturalist 137:388-392.

Dobkin, D. S., R. D. Gettinger, and M. G. Gerdes. 1995. Springtime movements, roost use, and foraging activity of Townsend's Big-eared Bat (*Plecotus townsendii*) in central Oregon. Great Basin Naturalist 55:315-321.

Gates, J. E., G. A. Feldhamer, L. A. Griffith, and R. L. Raesley. 1984. Status of cave-dwelling bats in Maryland: importance of marginal habitats. Wildlife Society Bulletin 12:162-169.

Genter, D. L. 1986. Wintering bats of the Upper Snake River Plain: occurrence in lava-tube caves. Great Basin Naturalist 46:241-244.

Hendricks, P., and D. L. Genter. 1997. Bat surveys of Azure Cave and the Little Rocky Mountains: 1996. Montana Natural Heritage Program. Helena, MT. 25 pp.

Hoffmann, R. S., D. L. Pattie, and J. F. Bell. 1969. The distribution of some mammals in Montana. II. Bats. Journal of Mammalogy 50:737-741.

Howard, P. E., and D. Hintzman. 1964. Zortman Cave survey project. Unpublished U.S. Forest Service Memo 2300 (2800). Lewis and Clark National Forest. 8 pp.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana Bat, *Myotis sodalis*. Florida Science 41:65-76.

Humphrey, S. R., and T. H. Kinz. 1976. Ecology of a Pleistocene relict, the Western Big-eared Bat (*Plecotus townsendii*), in the southern Great Plains. Journal of Mammalogy 57:470-494.

Jones, J. K., Jr., R. P. Lampe, C. A. Spenrath, and T. H. Kunz. 1973. Notes on the distribution and natural history of bats in southeastern Montana. Occasional Papers, The Museum, Texas Tech University, Number 15. 12 pp.

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation, Terrestrial Series #8. 53 pp.

Nagorsen, D. W., A. A. Bryant, D. Kerridge, G. Roberts, A. Roberts, and M. J. Sarell. 1993. Winter bat records for British Columbia. Northwestern Naturalist 74:61-66.

Ormsbee, P. C., and W. C. McComb. 1998. Selection of day roosts by female Long-legged Myotis in the central Oregon Cascade Range. Journal of Wildlife Management 62:596-603.

Perkins, J. M., J. M. Barss, and J. Peterson. 1990. Winter records of bats in Oregon and Washington. Northwestern Naturalist 71:59-62.

Priday, J., and B. Luce. 1997. Inventory of bats and bat habitat associated with caves and mines in Wyoming: completion report. Pp. 50-109, *In* Endangered and nongame bird and mammal investigations annual completion report. Unpublished report, Nongame Program, Wyoming Game and Fish Department. 234 pp.

Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack, Jr. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana Bats (*Myotis sodalis*). Conservation Biology 7:407-415.

Schowalter, D. B. 1980. Swarming, reproduction, and early hibernation of *Myotis lucifugus* and *M. volans* in Alberta, Canada. Journal of Mammalogy 61:350-354.

Schowalter, D. B., and J. R. Gunson. 1979. Reproductive biology of the Big Brown Bat (*Eptesicus fuscus*) in Alberta. Canadian Field-Naturalist 93:48-54.

Schowalter, D. B., J. R. Gunson, and L. D. Harder. 1979. Life history characteristics of Little Brown Bats (*Myotis lufcifugus*) in Alberta. Canadian Field-Naturalist 93:243-251.

Smith, H. C. 1993. Alberta mammals, an atlas and guide. Provincial Museum of Alberta. Edmonton, Alberta. 239 pp.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry, second edition. W. H. Freeman, San Francisco. 859 pp.

Swenson, J. E. 1970. Notes on distribution of *Myotis leibii* in eastern Montana. Blue Jay 28:173-174.

Swenson, J. E., and J. C. Bent. 1977. The bats of Yellowstone County, southcentral Montana. Proceedings of the Montana Academy of Sciences 37:82-84.

Swenson, J. E., and G. F. Shanks, Jr. 1979. Noteworthy records of bats from northeastern Montana. Journal of Mammalogy 60:650-652.

Tuttle, M. D. 1979. Status, causes of decline, and management of endangered Gray Bats. Journal of Wildlife Management 43:1-17.

Tuttle, M. D., and D. A. R. Taylor. 1994. Bats and mines. Bat Conservation International Resource Publication Number 3. 41 pp.

van Zyll de Jong, C. G. 1985. Handbook of Canadian mammals. 2. Bats. National Museum of Natural Sciences. Ottawa, Ontario. 212 pp.

Vonhof, M. J., and R. M. R. Barclay. 1997. Use of tree stumps as roosts by the Western Long-eared Bat. Journal of Wildlife Management 61:674-684.

Table 1. Seasonal location of hibernating bats in Azure Cave, Little Rocky Mountains, Montana, using all available sources. Most individuals are Myotis spp. (see text for more details). Dashes indicate the total count includes bats from unspecified portions of the cave.

	Room					
Date	Big	Lunch	Music	Gnome Home Area	C Passage	Total
5 Mar 1993[a]	9	250-300	no survey	4	no survey	263-313
1 Apr 1978[b]	3	482	37	0	7	528
18 Apr 1998[c]	6	972-1015	92-94	5-7	20-22	1101-1138
20 Apr 1997[c]	1	1057-1167	97-131	12	7	1174-1318
4 Jun 1996[c]	0	419-423	—	—	—	434-443
9 Jul 1978[b]	0	0	0	0	0	0
9 Aug 1991[d]	—	ca. 20	—	—	—	ca. 20
11 Aug 1978[b]	—	—	—	—	—	4
30 Sep 1978[b]	0	470	12	3	7	492
12 Nov 1998[c]	6	1273-1529	121-153	45-52	12-17	1457-1751

[a] Butts (1993).

[b] Chester et al. (1979).

[c] This study (1996-1998).

[d] Don Sasse personal communication, and in Butts (1993).

Table 2. Sex ratios of bats captured at Azure Cave, Little Rocky Mountains, Montana, during 1996-1998 (unless indicated otherwise). Statistical analyses test for a significant deviation from a 1:1 ratio, for species where n > 10.

Species	Total	Males	Females	G^a
Myotis ciliolabrum	5	1	4	—
Myotis evotis	5[b]	2	3	—
Myotis lucifugus	107[c]	93	14	65.197**
Myotis volans	14[d]	11	3	4.692*
Myotis species	1	1	0	—
Eptesicus fuscus	80[e]	65	15	33.780**
Corynorhinus townsendii	6[f]	2	4	—

[a] G-test for goodness-of-fit, William's correction: * - $P < 0.05$, ** - $P < 0.001$.

[b] includes 1 male from Butts (1993).

[c] includes 1 male, 1 female from Chester et al. (1979); 5 males, 2 females from Butts (1993).

[d] includes 1 male, 1 female from Chester et al. (1979); 1 female from Butts (1993).

[e] includes 5 males from Butts (1993).

[f] includes 2 females from Butts (1993).

Table 3. Weight (g) and forearm length (mm) of male and female Eptesicus fuscus from the Little Rocky Mountains, Montana, 1996-1998. Numbers are means ± SD, with sample sizes in parentheses.

		Males	Females	t^a
Jul				
	Weight	16.2±1.2 (6)	—	—
	Forearm	45.3±0.9 (6)	—	—
Sep				
	Weight	21.7±2.0 (38)	24.2±2.5 (11)	3.39*
	Forearm	45.1±1.4 (37)	46.9±1.5 (11)	4.24**
Oct				
	Weight	19.3±1.2 (24)	21.8±1.7 (4)	3.60*
	Forearm	46.2±1.6 (24)	47.0±1.4 (4)	0.94

[a] Two-sample t-test: * $P < 0.01$, ** $P < 0.001$.

Figure 1. Azure Cave, in the Little Rocky Mountains of Phillips County, Montana. Modified, with permission, from Campbell (1978).

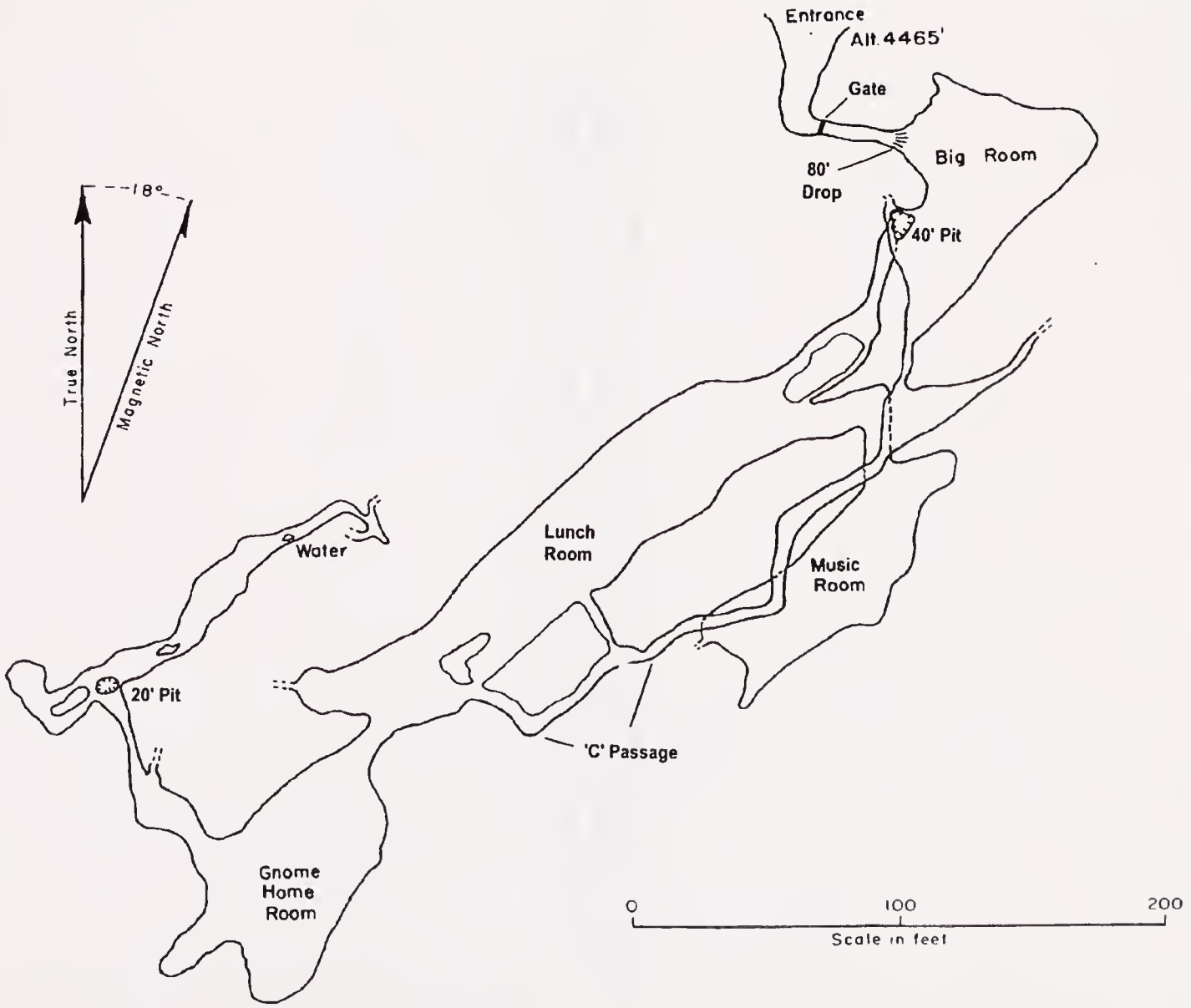

Entrance
Alt. 4465'
Gate
Big Room
80'
Drop
40' Pit
18°
True North
Magnetic North
Water
Lunch
Room
Music
Room
20' Pit
'C' Passage
Gnome
Home
Room
0
100
200
Scale in feet

Figure 2. Maximum hibernation counts of bats in Azure Cave for different years (sources: 1978 - Chester et al. 1979; 1993 - Butts 1993; 1996 - Hendricks and Genter 1997; 1997-1999 - this study). The 1993 count was incomplete, the 1996 count may have occurred after spring emergence began (both indicated with question marks).

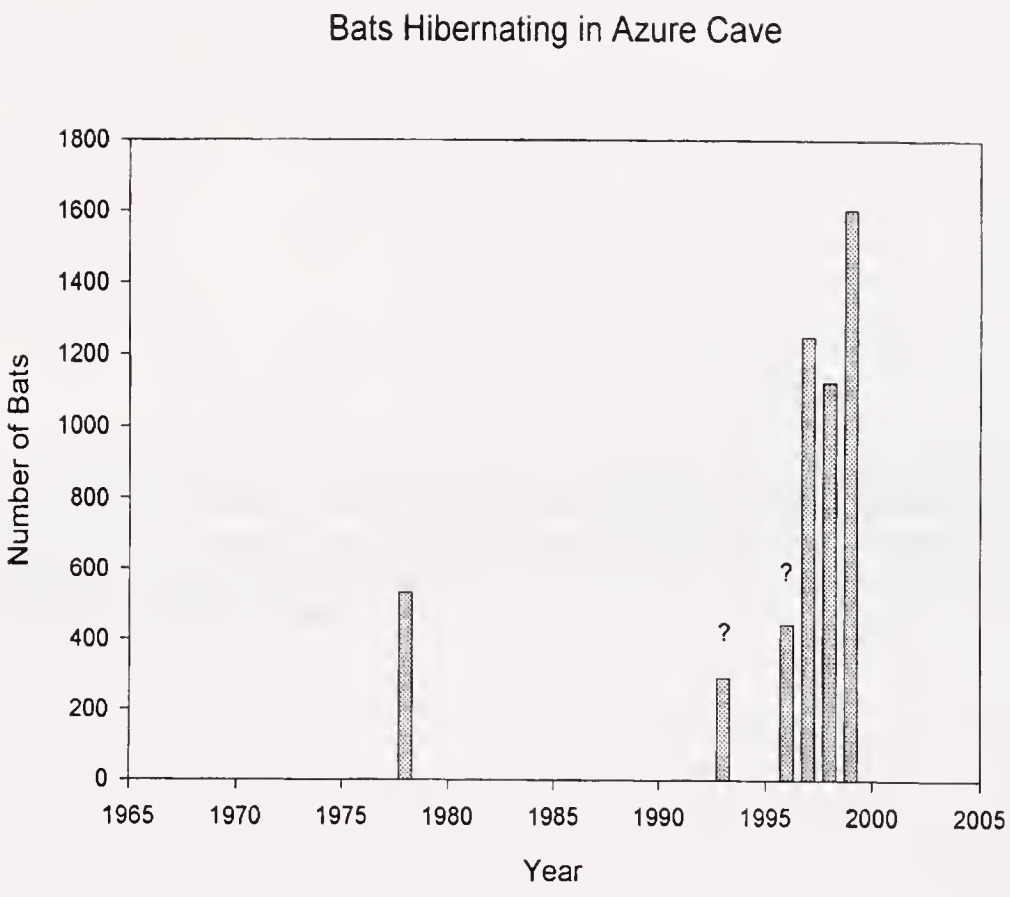
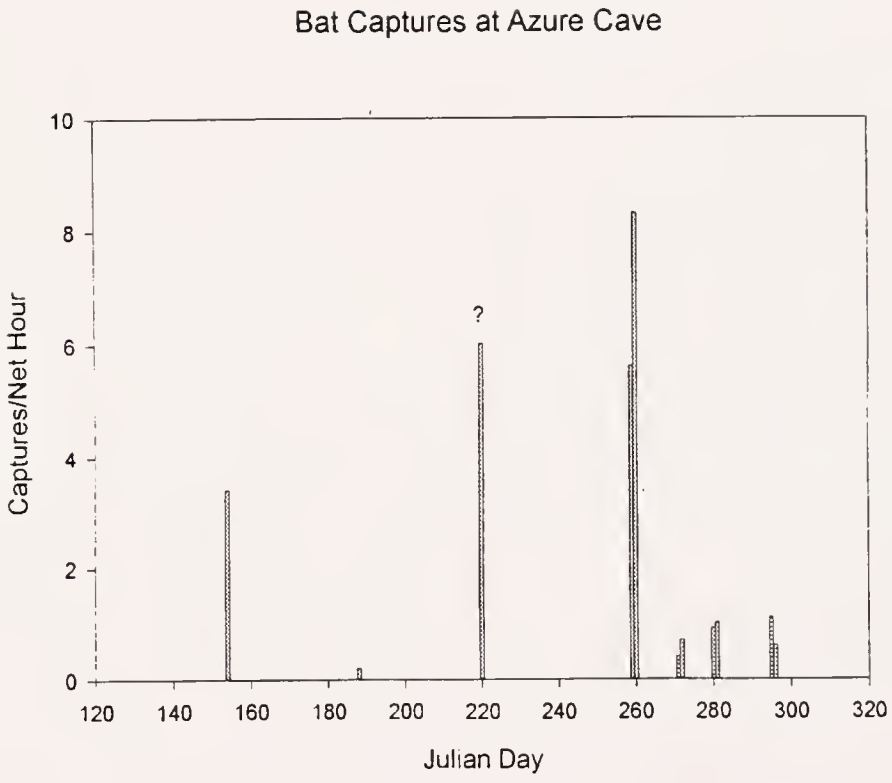

Bats Hibernating in Azure Cave
Number of Bats
1800
1600
1400
1200
1000
800
600
400
200
0
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year
?
?

Figure 3. Mist-net capture rates of bats at the mouth of Azure Cave during the active season, where day 1 = 1 January. Values do not include individuals recaptured during the night of initial capture. Question mark indicates that the value for day 220 (8 August) is not verifiable. Sources of data include Butts (1993), D. Sasse (personal communication), and Hendricks and Genter (1997).


Bat Captures at Azure Cave
Captures/Net Hour
10
8
6
4
2
0
?
120
140
160
180
200
220
240
260
280
300
320
Julian Day